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Tree roots affect subsoil aggregation and microbial community composition

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Subsoils store up to 70 % of the global soil organic carbon (SOC) stocks and may act as key carbon (C) sinks given appropriate management. A major input pathway of organic matter (OM) to subsoils is rhizodeposition which triggers biological, chemical and physical processes in the surroundings of plant roots, leading to the formation of the so-called rhizosphere. However, knowledge on SOC dynamics and especially stabilisation mechanisms, such as soil aggregation, in the rhizosphere of subsoils is very limited.

In this study, we planted European beech (Fagus sylvatica L.) seedlings in topsoil and subsoil material from three beech forest sites that developed on different parent materials (red sandstone, loess, pleistocene sands). During a growth period of five months, the seedlings developed a dense root system that affected the whole soil volume inside the pots. This controlled experimental setup enabled us to sample relatively large amounts of rhizosphere soil. For each soil, unplanted controls were established. Samples were analysed for organic carbon (OC) and N, phospholipid fatty acids (PLFA) were extracted to investigate the microbial community composition, the activities of eight extracellular enzymes were measured, and extracellular polymeric substances (EPS) were quantified. Furthermore, the soils were subjected to an aggregate fractionation, yielding macroaggregates (> 250 μm), as well as different size classes of microaggregates (250-53 μm, 53-20 μm, < 20 μm).

First results indicate that rooting effects vary between different soil types and soil depths. In the red sandstone and the loess soil, soil structure (measured as aggregate distribution) was strongly affected by rooting. However, the effects were contrary for topsoil and subsoil. In the topsoil, relative distribution of macroaggregates was significantly lower in the rhizosphere samples as compared to the unplanted control pots. In contrast, macroaggregation increased strongly in the subsoil rhizosphere, potentially triggered by a microbial community shift towards fungi. This might enhance the protection of SOC from degradation and thereby increase subsoil C sequestration. For the loess site, an increase in subsoil OC concentrations due to rooting was already visible in this medium-term experiment. Moreover, microbial biomass and enzyme activities tend to increase with rooting in the subsoil of all sites.

Our study shows that plant roots affect deep soil OC dynamics in a very different way than those of topsoils and thus may contribute to subsoil C sequestration via input of OM and associated shifts in microbial community and soil structure.